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A CAI Instructional Design View of Teaching Concepts

by

R. Neil Moore

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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Edmonton, Alberta

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Dedication

This thesis is dedicated to my parents, Grace and Dick Moore, whose love of teaching and students has been a source of inspiration to me.

Abstract

The purpose of this study was to use computer-assisted instruction to apply three distinct instructional strategies in the teaching of the statistical concept of random experiment. The three instructional strategies were Attribute Identification, Example Comparison and a combination of Attribute Identification & Example Comparison. Forty-eight students in the first year of a two-year business program at the Northern Alberta Institute of Technology answered seven questions during instruction, and ten questions during each of two delayed tests: a posttest administered immediately following instruction, and a retention test administered one week later. Each question asked the student to read the information shown on the display screen of the computer terminal and then to indicate whether an example or nonexample of the concept of random experiment was presented. There was no difference in achievement scores among the three treatment groups at the 0.10 level of significance.

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Rick Bell meticulously produced the flowcharts in Appendix D. Phil McKenzie, Dave Matheson and Horst Mueller cheerfully shared their Textform expertise.

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I. Chapter One

Introduction

Computer-assisted instruction (CAI) grew out of programmed instruction and teaching machines (Gentile, 1967). Computer-assisted instruction was defined by Towle (1978) as "involving instructional uses in which the computer directly assists in the teaching and/or presentation of learning materials." The great challenge in the use of computer-assisted instruction is to deliver quality instruction. If inadequate planning takes place before courseware is developed, then the use of the computer to deliver instruction merely results in poor instruction delivered by impressive technology. Hall (1983) stated that " deep cognitive processing does not necessarily take place while the learner 'watches' a program execute on a computer". The proper use of instructional design techniques helps to ensure that this self-defeating process does not take place.

Bunderson (1970) defined the two basic aspects of instructional design as:

> Instructional [aspects] involve education disciplines especially educational psychology, involving human learning, psychometrics, programmed instruction and individual differences.
>
> Design implies a problem oriented engineering approach, an interactive empirically oriented pragmatic approach. (p 13)

Kearsley (1977) and Bunderson viewed instructional design and CAI as being bound together. Kearsley presented

the analogy that using CAI without the adequate use of instructional design is like using a supersonic jet to spray farm crops. Bunderson equated the claim that an author can function without instructional design techniques to the claim by an eighteenth century farmer that a field of corn would grow without the help of an agricultural agent. Tennyson and Park (1984) stated that they are led to discuss educational computing in terms of learning theory, instructional design and technology theory.

Purpose of the Study

The purpose of this study was to apply and examine the effects of three distinct instructional strategies on the teaching of the statistical concept "random experiment." Based upon each of the three instructional strategies, three separate modules of computer-based courseware were developed and delivered on a computer-assisted instructional system to three groups of NAIT first year business students.

Statement of the Problem

The three instructional strategies referred to above grew out of different approaches which are often taken to the learning of a concept. Concept learning is an area that has been studied by experts in many different fields. Grant (1983) chronicled some of the traditional research interests that psychologists have had in concept learning:

> Experimental psychologists in the area have had a penchant for studying conceptual behavior and

> categorization in ways that are not particularly relevant to the way these processes transpire in natural, and especially, classroom settings. For example, a great deal of research has been devoted to studying the learning of concepts defined in terms of rather exotic relationships among critical features despite the paucity of any such natural concepts. (p 7)

Smith and Medin (1981) described the classical view of concepts in which concepts are comprised of critical features (Bruner, Goodnow and Austin , 1956) and the alternative prototype view in which a concept (for example, a natural concept like toy or bird) has an internal structure such that it consists of certain central instances surrounded by less typical instances (Rosch, 1973). Gleitman, Armstrong and Gleitman (1983) demonstrated that experimental results, which showed either the classical view or the alternative prototype view as being correct, depended on the methods used. In conducting research on the teaching of concepts, instructional designers have used both the classical and the prototype view; Tennyson, Chao & Youngers (1981), Tennyson, Youngers & Suebsonthi (1983) and Park (1984) have carried out research in the area. The instructional strategy which is based on the classical view was named Attribute Identification Strategy (AIS) by Park. The instructional strategy based on the prototypical view was named Example Comparison Strategy (ECS).

Hypothesis

The hypothesis tested was that the combination of ECS (Example Comparison Strategy) and AIS (Attribute

Identification Strategy) would result in better learning than using either ECS or AIS alone.

Definitions and Terminology

Attribute Identification Strategy (AIS) -This is an instructional strategy in which the student is presented the important attributes of a concept; the presence or absence of these attributes is used to indicate examples or nonexamples of the concept.

Algorithm-An orderly procedure for obtaining a particular result or solving a problem. (Garroway, 1983)

Authoring Language-A special-purpose programming language designed to facilitate the development of CAI-type programs. (Chambers and Sprecher, 1983, p 199).

Courseware-Instructional material presented via computer.

Digital Equipment Corporation (DEC) -A computer manufacturer.

Dimension Authoring Language (DAL) -Authoring language developed by DEC for use on the VAX system. (Dimension Authoring Language Reference Manual, 1982).

Dimension Authoring System-Software developed by DEC to facilitate the production of courseware, registration of students and recording of student data on the VAX system. (Dimension Authoring System User's Guide, 1982)

Example Comparison Strategy (ECS) -This is an instructional strategy in which the student is presented with "best" examples of the concept and then uses those best examples to

decide whether another sequence is an example or nonexample of that concept.

Instructional Strategy-The means and procedures for providing instruction in a manner consistent with learning theory. (Chambers and Sprecher, p 201) In this study the instructional strategies were AIS, ECS and AIS & ECS.

Mode-Method of presenting an example or nonexample - either interrogatory (questioning) or expository (statement form).

Northern Alberta Institute of Technology (NAIT) -Two-year technical institute in Edmonton, Alberta.

On-task-Testing condition in which responses are captured while the student goes through the courseware.

Plaza I-Satellite campus of the Northern Alberta Institute of Techology, located five city blocks east of the main campus.

Posttest-Testing condition presented immediately following instruction.

Retention Test-Testing condition given one week after the posttest.

Statistical Package for the Social Sciences (SPSS) -a series of statistical programs run on a computer. (Hull and Nie, 1981)

Testing Condition-one of on-task, posttest and retention tests.

Treatment group-Students were divided into groups depending on whether the instructional strategy of AIS, ECS or AIS & ECS was used.

VAX 11/750-A computing system which is a member of the Digital Equipment Corporation (DEC) VAX 11 family.

Significance of the Study

The study was significant in that it was an attempt to increase our knowledge of the best approach to be used when designing instructional materials to be presented to an adult learner via computer-assisted instruction.

II. Chapter Two

Introduction

Review of the Literature

The review of the literature consists of two parts:

1. Definition of the term concept, with emphasis on
   a) definition of related terms,
   b) attributes vs prototype.
2. Instructional design implications.

The review of theoretical material was obtained primarily from that found in experimental psychology. It serves as a context from which to examine the teaching of concepts and the importance of this perspective to the instructional designer.

Definition of Concept

There is a wide variance in the definition of the term concept. (Klausmeier, Ghatala and Frayer, 1974; Flavell, 1970 ; Klausmeier and Harris, 1966). Flavell stated that "the search for a satisfactory definition of the term 'concept' is a lexicographer's nightmare. " Both Martorella et al. (1972) and Gagne (1966) offered a potpourri of different definitions of concept. A subsample of four definitions taken from Martorella's sample of eight definitions of concept (p 2 -3) is:

> 1. A concept is a kind of unit in terms of which one thinks; a unit smaller than a judgement,

proposition or theory, but one which necessarily enters into these. (Gould and Kolb [Eds.], 1964, p 20).

2. In brief, concepts are properties of organismic experience.....more particularly they are the abstracted and often cognitively structured classes of mental experience learned by organisms in the course of their life histories. (Carroll 1964, p 180).

3. A concept may be thought of as the common element shared by an array of objects or the relationship between the constituents or parts of a process. (George 1962, p 260).

4. A concept is a general idea, usually expressed by a word, which represents a class or group of things or actions having certain characteristics in common. (Quillen and Hanna 1961, p 187).

Gagne also offered Carroll's definition (see 2 above), but gave some additional definitions from the literature. He then looked at the common properties shared by these definitions:

> Berlyne (1965) believed that a concept is formed when overt behavior comes to depend on certain properties of a stimulus pattern while disregarding other properties. "It means forming what logicians and mathematicians call an 'equivalence class' of stimulus situations, which share some characteristics but are distinct in other respects,and performing the same response to all members of the class"(p 45).
>
> Kendler (1964) defined concept learning as the acquisition of a common response to dissimilar stimuli. But he also went on to say that concepts are associations, and that they function as cues or mediators of learned behavior. This conception of the concept is basically similar to that of Osgood (1953) who emphasized the acquisition of a mediating process that can be "detached" or "abstracted" from the stimulus objects with which it may initially have been associated.....
>
> All these definitions have some general properties in common,and I judge these to be as follows.
> 1. A concept is an inferred mental process.
> 2. The learning of a concept requires discrimination of stimulus objects

(distinguishing positive and negative instances)

3. The performance which shows that a concept has been learned consists in the learner being able to place an object in a class.

Two additional attempts at definition of concept are germane. Anglin (1977) defined a concept as all of the knowledge possessed by an individual about a category of objects or events. Medin and Smith (1984) after noting that the term is a "loaded one as it serves several explanatory functions within psychology and related disciplines," followed Rey (1983) in offering four functions that concept serves in psychology and related disciplines:

1. Simple categorization: the means by which people decide whether or not something belongs to a simple class. (e.g., boy).
2. Complex categorization: the means by which people decide whether or not something belongs to a complex class.
3. That part of the meaning of a term that explains semantic implication (that part of the meaning of "boy" that explains why it is roughly synonymous to lad and implies being male and young).
4. Components of cognitive states:in this role concepts are what provide a cognitive explanation of complex thought and behavior . (p 114)

Medin and Smith then stated that the first function, simple categorization, has been the major focus in the literature concerning itself explicitly with concepts; they took "concept" to mean a mental representation of a simple class.

Horton and Turnage (1976) distinguished among three different theories of conceptual behavior: association theories, hypothesis testing theories and information processing. Association theories emphasize positive and

negative instances of a concept and the responses required of a student. Baine's (1983) hierarchy falls into the category of association theory. Before considering Baine's concept hierarchy, a definition of terms is necessary:

Discrimination-to make a different response to one of two different object members of a particular group (Gagne, 1977, p 104).

Generalization- the learner exhibits a particular response in one stimulus situation which he/she acquired in a similar stimulus situation (Merrill and Tennyson, 1977).

Defining Attribute- an attribute which is necessary in order to determine whether an instance is or is not an example of a concept.(Klausmeier et al. , 1979, p 15).

Baine (1983) developed a useful hierarchy of discriminations and concepts:

1. simple discriminations
2. multiple discriminations
   a. discrimination of one example from two or more specific nonexamples
   b. discrimination of two or more specific examples from one nonexample
   c. discrimination of two or more specific examples from two or more specific nonexamples
   d. discrimination of two or more examples; the learner is tested on his ability to generalize his discrimination to other examples.
3. concepts- concept involves the discrimination of two or more examples from two or more nonexamples; the learner is tested on his ability to generalize his discriminations to other examples and nonexamples.

It is clear that Baine would define the three critical attributes of a concept to be discrimination between classes, generalization outside the class, and generalization inside the class. Note that Baine's hierarchy

conforms to two of Gagne's general properties: discrimination and generalization. Klausmeier, Ghatala and Frayer (1974) listed the attributes of concept as learnability, usability, power, structure, instance perceptibility and instance numerousness.

With reference to Gagne's shared characteristic that a concept is an inferred mental process, Bourne, Dominowski and Loftus (1979) provided an excellent introduction to concept as a mental process. Rather than the memory representation of a concept taking the form of defining features, another possibility is a Gestalt or holistic interpretation in which concepts are represented by their best examples or prototypes. (Rosch, 1975) .

Rosch (1978) spoke of the internal structure of concepts. She said that one way to achieve distinct categories is to have formal, necessary and sufficient criteria for category membership. Another way is to conceive of each category in terms of its clear cases rather than its boundaries. She quoted Wittgenstein (1953) :

> .....categorical judgements become a problem only if one is concerned with boundaries - in the normal course of life, two neighbours know on whose property they are standing without exact demarcation of the boundary line. (p 35-36)

Both Medin and Smith (1984), who drew to a large extent on their own review (Smith and Medin, 1981), and Millward (1980) reviewed alternative views of the structure of concepts. Medin and Smith pointed out that after two decades in which one view of the structure of concepts was dominant,

alternative views have emerged. Medin and Smith called this formerly dominant view the classical view and used the same description that Rosch used - necessary and sufficient attributes. Millward found four major theoretical positions, while Medin and Smith found three. Millward went into a great deal of detail in distinguishing among the various positions. He stated that no one theory explains all the experimental results and that it would be "ad hoc and unparsimonious" to construct a single theory by lumping all positions together.

In addition to the classical view, Medin and Smith spoke of the probabilistic and exemplar views. Even though the experimental psychologist would likely see important distinctions between the probabilistic and exemplar views, Medin and Smith referred to both as prototype concepts because the concept does not contain defining properties.

Gleitman, Armstrong and Gleitman (1983) took the classical concept of odd number and used the Rosch group's techniques. They found that the same sort of results were obtained as those for the natural language categories like fruit or vegetable. They hypothesized that the results were due to the method used and not necessarily indicative of the structure of the concept. Gleitman, Armstrong and Gleitman described Landau's (1982) work which showed it is useful to have two representations of the same concept:

> For example, suppose you want to find a grandmother in Yankee Stadium. It pays to have a workable representation of likely grandmother candidates for these rough identification purposes. You ought to

> look around for a gray-haired lady with a twinkle in her eye, preferably one dispensing brownies. This is faster than making genealogical enquiries. But to reason about the concept grandmother you had better refer to a representation that stipulates that grandmothers are mothers of parents. (p 102)

Hall (1983) distinguished between learning concepts by attribute isolation and identification versus prototype acquisition. Park (1984) referred to the example comparison strategy (ECS) and the attribute identification strategy (AIS). Haygood and Bourne (1965) defined a concept both in terms of relevant attributes and a rule applied to those attributes to determine category membership. Fourteen years later Bourne, Dominowski and Loftus (1979) stressed the same point but, in addition, stressed Rosch's work. Both Hall and Park suggested that a possible approach might be a combination of the two strategies.

Instructional Design Implications

Tennyson & Jassal (1982) and Tennyson & Park (1980) provided reviews of the teaching of concepts from an instructional design perspective. Bourne, Dominowski and Loftus cited Rosch's (1973) criticism of laboratory research in concept formation because of its lack of concern with the structure of concepts and the fact that the stimulus material on which conceptual problems have been structured is relatively simple, highly dimensionalized and artificial. Tennyson, Chao and Youngers (1981) stated categorically that:

> The research paradigm followed most often in experimental psychology therefore has little to do with the learning of concepts per se: It involves a type of problem solving in which stimuli are chosen from combinations of several independent dimensions and in which the subject's task is to sort or classify the stimuli according to a simple rule. At this time, the most successful efforts from this type of research (mathematical models for attribute learning with a one-dimensional rule) do not seem capable of being generalized to applied problems of concept learning in the classroom. (p 326)

Therefore, the learning of concepts in a realistic situation where the structure of concepts is important is of interest. Tennyson, Chao and Youngers hypothesized that concept learning is a twofold process involving:

1. acquisition of a prototype through clear statements of best examples.
2. development of skills in generalization and discrimination through the practice of contrasting the prototype with newly encountered examples and nonexamples.

Their finding was that the second process of classification skill can be learned most effectively if learners are given both expository and interrogatory presentation forms. Using the concept of a regular polygon with Grade 3 students, Tennyson, Youngers and Suebsonthi (1983) found that the use of a best example (ECS), as opposed to an operational rule (AIS) led to better abstraction of the concept class as a prototype. Park also tested the effectiveness of ECS against AIS with a set of abstract verbal concepts. He was interested in the relative difficulty of generating clear

examples and the impact of the different degrees of concept abstractness on the effectiveness of the strategy. ECS was more effective for posttest and retention; for on-task, AIS was more effective. Notice that while Medin and Smith spoke of prototype concepts versus rule concepts, the instructional designers used the two different approaches for the same concept.

III. Chapter Three

Introduction

Statement of the Problem

Two hypotheses were examined in this study; both closely follow the work of Park (1984).

1. The combination of ECS (example comparison strategy) and AIS (attribute identification strategy) will result in better learning achievement than either ECS or AIS alone during three evaluation periods (instruction, posttest and retention test).
2. Students in the group receiving a combination of ECS and AIS will produce more acceptable definitions and more acceptable examples of the concept of random experiment than those students receiving only ECS or AIS .

The level of significance for the statistical tests was set at 0.10.

Design of Study

Sample

Tennyson, Chao & Youngers used fourth grade students and Tennyson, Youngers & Suebsonthi used third grade students in their studies; Park used twelfth grade students. First year students from the two-year business program at NAIT were used in this study. The population of first year

business students in the fall of 1984 was approximately 480. The majority of students were between 18 and 25 years of age. The de facto requirements for admittance to the business program are a high school diploma (including English) with at least 50 per cent in Mathematics 30 and English 30.

The sample size was 48 students. Students participated on a volunteer basis. The original intention was to have a sample size of 60 students, but only 54 of the 60 students who were recruited appeared. Data for four students were not fully recorded by the authoring system. To achieve balance in the three treatment groups, two additional students were dropped from the study: one student who wrote the retention test two and a half weeks (rather than one week) after the posttest and a second student whose English proficiency was judged to be poor. Thus the final sample size was 48.

When the students in the study contacted the investigator to indicate their intention to volunteer, they were assigned sequential numbers on a first-come, first-served basis. The students were then randomly divided into the three treatment groups by selecting corresponding numbers from a random number table.

Instrument

The computer system used was one of the three DEC VAX 11/750 computer systems at NAIT's Plaza I site in Edmonton; these three computer systems currently are run independently. The amount of random access memory on each system is

four megabytes (4 million characters); each system can handle a maximum of 32 terminals. The GIGI (General Imaging Generator and Interpreter) color terminal was used by the students. The courseware was written in the Dimension Authoring Language (DAL) and run under the Dimension Authoring System. A number of common routines and a "driver program" (as used by the Computer Systems and Services Division at NAIT) were used as the starting point in the development of the computer-based courseware. Most of these program routines were substantially modified or replaced during the courseware development phase. Approximately 350 hours was spent by the investigator in developing the courseware used in this study.

The courseware consisted of three distinct modules; however, each module used the same introductory material. The variation in the modules was due to the use of three distinct instructional design strategies (AIS, ECS and AIS & ECS) . Each of the three treatment groups was assigned to one of the three instructional strategies. The same four examples and six nonexamples were used in each module. Three were presented in expository mode, and seven were presented in interrogatory mode. Table 1 shows the sequence of the examples and nonexamples and whether the expository or interrogatory mode of presentation was used.

Table 1

Sequence of Example/Nonexamples Showing Mode

Sequence	Mode	E.g./None.g.	On-task Questions
1	Expository	Example	
2	Interrogatory	Nonexample	1
3	Interrogatory	Example	2
4	Expository	Nonexample	
5	Interrogatory	Nonexample	3
6	Interrogatory	Example	4
7	Interrogatory	Nonexample	5
8	Expository	Nonexample	
9	Interrogatory	Example	6
10	Interrogatory	Nonexample	7

The concept taught in this study was that of the statistical random experiment. A random experiment is defined as a process with the following three properties:

1. It can be repeated.
2. All possible outcomes can be specified or listed in advance.
3. If the process is repeated many times, the same outcome will not always occur.

Attribute Identification Strategy (AIS)

The definition of a random experiment was presented to students as the three-point rule shown above. The ten examples/nonexamples were then presented, and in each case access was offered to a help page where the rule was given in the form shown above. The algorithm governing the presentation differed depending on whether the expository or interrogatory mode was used. Flowcharts illustrating the two presentation algorithms are included in Appendix D. The algorithm for the interrogatory mode is described below in logical English.

1. Present an example or nonexample.
   a. If requested, access the help page.
2. Accept a yes or no response which indicates whether this is or is not a random experiment .
   a. If the response is correct, give positive feedback and present the next example or nonexample. [1]
   b. If the response is incorrect, execute statements [4] to [6].
3. Execute statement [4] for each of attributes 1 to 3.
4. Accept a response indicating the presence or absence of an individual attribute.
   a. If the first response is correct, give positive feedback and go on to the next attribute. [3]
   b. If the first response is incorrect, give a hint and then accept the second response.
   c. If the second response is correct, give positive

feedback and go on to the next attribute. [3]

d. If the second response is incorrect, give feedback indicating that it must be the other response (since yes or no are the only acceptable responses) and go on to the next attribute. [3]

5. Accept a response indicating whether this is or is not a random experiment.

   a. If the first response is correct, present positive feedback and present the next example or nonexample. [1]

   b. If the first response is incorrect, give a hint and then accept the second response.

   c. If the second response is correct, give positive feedback and present the next example or nonexample. [1]

   d. If the second response is incorrect, give feedback indicating that it must be the other response and present the next example or nonexample. [1]

Example Comparison Strategy (ECS)

In ECS, the definition was presented once, and then access was given to the help page, which contained the following two "best" examples:

1. Draw a ball from a container with
   SEVEN colored balls.
   THREE are red and FOUR are yellow.
   The outcome of interest is the color
   of the ball drawn.
2. Randomly choose a business administation class.
   There are FORTY students in each class.
   The outcome of interest is the number of
   MALES and FEMALES in each class.

Again the example or nonexample was presented except that now the help page contained the two best examples. Two flowcharts illustrating the presentation algorithms used for the ECS treatment group are included in Appendix D.

Combination of AIS & ECS

Half of the examples/nonexamples used the AIS format while the other half used the ECS. The table below shows the sequence of examples/nonexamples and the mode and instructional strategy used.

Table 2

Sequence of Examples/Nonexamples
Showing Mode and Instructional Strategy

Sequence	Mode	E.g./None.g.	Strategy
1	Expository	Example	AIS
2	Interrogatory	Nonexample	AIS
3	Interrogatory	Example	ECS
4	Expository	Nonexample	ECS
5	Interrogatory	Nonexample	AIS
6	Interrogatory	Example	AIS
7	Interrogatory	Nonexample	ECS
8	Expository	Nonexample	ECS
9	Interrogatory	Example	ECS
10	Interrogatory	Nonexample	AIS

Appendix E contains the ten posttest questions. Appendix F shows a sample run of courseware for the AIS & ECS treatment group; the sequential order of the questions was determined by a random number generator.

Procedure

On-line testing

Students were randomly assigned to the three treatment groups. The program was designed in such a way that on-task performance scores were collected for the seven interrogatory mode questions in each treatment group. The posttest and retention tests consisted of ten questions (five examples and five nonexamples) which were presented in random order. The retention test was a stand-alone copy of the posttest and was administered one week after the posttest.

Questionnaire

The 48 students in the three treatment groups were also asked to complete a three-item questionnaire. Of the 16 students in each of the 3 treatment groups, 8 students were asked to complete the questionnaire immediately after taking the retention test and the remaining 8 students were asked to complete the questionnaire one week after the retention test. The students were asked three items:

1. When I say random experiment to you, what do you think of ?
2. How would you describe a random experiment?
3. Give an example(s) of the concept of random experiment.

Each student answered the three items on a single sheet of

paper. Later, for Item 1, all of the students' reponses were rewritten onto a single set of sheets. Five of the students' responses were included twice. Thus, there was a total of 53 responses listed for Item 1.

The same procedure was carried out for Item 2, with the students' responses listed in a different order than for Item 1. The two sets of sheets (for Items 1 and 2) were duplicated and submitted to three subject matter experts who were asked to indicate whether each response was an acceptable definition of random experiment. For the third item, the presence of at least one acceptable example was assessed by the investigator.

Data Analysis

On-line Data

The treatment groups were Attribute Identification Strategy (AIS), Example Comparison Strategy (ECS) and a combination of AIS & ECS. Each treatment group contained 16 students. Each student had a set of three scores, indicating the number of correct responses for the on-task, posttest, and retention test. A one-way multivariate analysis of variance (Manova) was run using SPSS (Release 9). The data used in the analysis are included in Appendix B. The results of the Pillai (1967), Hotelling (1951), Wilks (1932) and Roy (1957) multivariate tests of significance were provided by SPSS, as well as univariate F tests on each of the on-task, posttest and retention tests. Responses were compared for each question on the posttest and retention test, and a phi coefficient was calculated for each question.

Questionnaire data

For each of Items 1 and 2, if two of the three subject matter experts agreed that a definition was acceptable, the student's response was deemed acceptable; the same rule was used for classifying unacceptable responses. When a student gave an acceptable definition for one of the items and not for the other, this was recorded. An acceptable definition for either item was counted as a correct answer and a total score accumulated for each treatment group. A chi square analysis was performed on these scores. In the case of each

subject matter expert, the number of mismatches between each of the five duplicated questions was noted for both items.

Pilot Study

A preliminary version of the courseware using the AIS approach was vetted by instructional designers, programmers and subject matter experts at NAIT. As well, 12 first year students went through the courseware. Changes were made to the courseware based upon the comments and suggestions from these groups.

Limitations

1. A small, one-time sample of postsecondary students was used.
2. No pretest was administered.
3. There was no NON-CAI control group.
4. The students were chosen from the general student population on a volunteer basis.

IV. Chapter Four

On-line data

The Dimension Authoring System recorded the students' responses on the on-task, posttest, and retention test. Each student's score on the on-task, posttest and retention test was calculated. The raw scores are listed in Appendix B. The on-task scores have been converted to base of ten; the number of on-task questions was seven, and the number of posttest and retention test questions was ten.

Table 3

Mean Number of Questions Correct

	AIS	ECS	AIS & ECS
On-Task	8.04	7.50	8.04
Posttest	7.13	7.63	7.32
Rettest	7.81	8.44	9.13

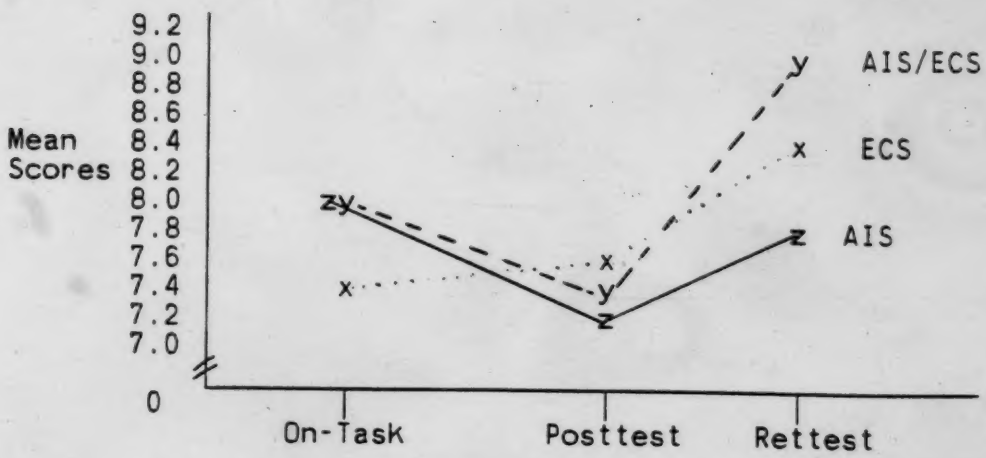


Figure 1. Mean Number of Questions Correct

Morrison (1976) stated that the only reliable multivariate test of significance is that by Roy (1957), as the others only assume their distributional properties(i.e., the F distribution) as the sample size approaches infinity. Table 4 shows the observed Roy test values and the probabilities for each testing condition.

Table 4

Statistical Test Results

Testing Condition	Statistical Test	Value	Probability
All	Roy	.14	>.10
On-task	F(2,45)	.33	>.10
Posttest	F(2,45)	.47	>.10
Retention	F(2,45)	2.67 *	<.10

At a level of significance of 0.05, using Phi coefficients, significant observed chi square values were found when testing the relationships between the responses to each of Questions 1, 7, 8, 9 and 10 on both the posttest and retention test. As this analysis does not relate specifically to the hypothesis under investigation, the tables are listed in Appendix A. The AIS, ECS and AIS & ECS treatment groups took an average of 22, 22 and 24 minutes respectively to complete the instructional portion of the modules.

Discussion

The Roy statistic showed that the three instructional strategies did not produce significantly different results on the three tests as a group. Nonetheless, the profile analysis (Fig. 1) was interesting. The comparison of ECS to AIS gave interesting results. The change in score from on-task to posttest was similar to that of Park (1984), with the AIS treatment group being better than the ECS during the on-task, but with the reverse on the posttest.

Park's study showed a similar drop in scores from the posttest to the retention test for both treatment groups, with the ECS treatment group maintaining an edge over the AIS treatment group. In this study, both treatment groups showed an increase in achievement scores from the posttest to the retention test. This could be attributed to the fact that with only 10 questions in both the post and retention tests, as opposed to 24 questions in Park's study, the reliablity of the results is lowered.

The results of the combined AIS & ECS treatment group partially supported the hypothesis. At the 0.10 level of significance, the mean scores for the retention test were different among treatment groups. Even though the posttest results for the combined AIS & ECS group fell below those for the ECS treatment group (mirroring the results of ECS versus AIS), the retention test showed superior results for the combined AIS & ECS group over the ECS group.

Questionnaires

The students' item responses to the questionnaire were analysed by three subject matter experts. Five unacceptable definitions and five acceptable definitions from the total set of responses are shown in Appendix C.

Table 5

Comparison of Response Categories for Items 1 & 2

	Item 2					
	AIS		ECS		AIS & ECS	
Item 1	right	wrong	right	wrong	right	wrong
right	5	2	0	5	5	1
wrong	4	5	2	8	5	5

Examination of Table 5 shows that two students from the AIS group and one student from the AIS & ECS group answered the first item correctly and the second item incorrectly. Four students from the AIS group and five students from the AIS & ECS group answered the second item correctly and the first item incorrectly. The reverse was true for the ECS group, where five students answered Item 1 correctly and Item 2 incorrectly and two students answered Item 2 correctly and Item 1 incorrectly. The AIS group and the AIS & ECS group were more inclined to give the correct definition when asked for a definition, while the ECS group was more inclined to give the definition when asked what they thought

of when they heard "random experiment."

Table 6

Number of Acceptable Definitions of Random Experiment

	One or Both of Items 1 & 2 Right		
	AIS	ECS	AIS & ECS
Immediate	6	4	5
Delayed	5	3	6

Park's results indicated more acceptable definitions were obtained from the ECS group than from the AIS group. The results of this investigation indicated no difference among the AIS, the ECS and the AIS & ECS groups (see Table 6) . The number of acceptable definitions was independent of the treatment group for both the immediate and the delayed groups (observed chi square (2)= 1.86 and 2.4 respectively) with $p > .10$ in both cases. The responses immediately after the retention test and one week after the retention test were virtually identical. Of the total of ten duplicate responses which were included in the sets of responses provided to each rater, each rater had only one mismatch.

Table 7

Number of Acceptable Examples of Random Experiment

	AIS	ECS	AIS & ECS
Immediate	7	8	8
Delayed	7	7	8

Examination of Table 7 shows that there were no differences in the number of examples provided by each treatment group.

V. Chapter Five

The purpose of this study was to use CAI to apply the instructional strategies of AIS, ECS, and AIS & ECS to the teaching of the statistical concept of random experiment. Three modules of computer-assisted instruction courseware were developed and delivered to three groups of NAIT first year business students.

Summary of the Study

The sample size was 48 students. The instrument consisted of three different courseware modules, but each module used the same introductory material. The variation in the modules was due to the use of three distinct instructional strategies.

The first strategy was called the Attribute Identification Strategy (AIS) . When presented with an instructional example or nonexample, the student was allowed access to a help page where the attributes and rule for concept membership were listed.

The second strategy was the Example Comparison Strategy (ECS) . The student was allowed access to a help page where two "best" examples were presented.

The third strategy was a combination of AIS & ECS.

During instruction four examples and six nonexamples were presented. Three were presented in expository mode, and seven were presented in interrogatory mode. A ten-question posttest containing five examples and five nonexamples was

given immediately following instruction. The same ten questions were used in the retention test, which was given one week after the posttest. A questionnaire asking the students to give a definition and examples of random experiment was completed. Eight of the sixteen students in each treatment group answered the questionnaire immediately after the retention test, and the remaining eight students in each treatment group answered it one week after taking the retention test. The definitions were rated as acceptable or unacceptable by three subject matter experts.

Major Findings

Hypotheses

Two hypotheses were examined. The first hypothesis, that the combination of ECS & AIS will result in better learning achievement than either ECS or AIS alone during instruction as well as on the posttest and retention test, was not supported. The second hypothesis, that students in the group receiving a combination of ECS & AIS will produce more acceptable definitions and more acceptable examples than those students receiving only ECS or AIS, was not supported. The level of significance used to test these hypotheses was 0.10.

Further examination of the data from the first hypothesis showed a difference among treatment groups for the retention test at the 0.10 level of significance. For

the retention test, the AIS & ECS treatment group showed the highest mean score. There was no difference in the number of acceptable definitions or examples among treatment groups.

Conclusions

There was no evidence shown to indicate that, in the teaching of a concept via CAI, the use of a combination of Attribute Identification Strategy and Example Comparison Strategy leads to results that are better than using the Attribute Identification Strategy or the Example Comparison Strategy alone.

Classroom/Courseware Implications

The posttest segment of the study demonstrated that questions must be clearly worded and pretested. Question 10 was dropped from the posttest during the pilot study because the students had difficulty interpreting it. The replacement question was not pilot-tested before being used in the study, and the students again had difficulty interpreting it.

In judging the acceptability of definitions by the subject matter experts, it appears that a question does not necessarily have a single, unique answer.

In a computer-assisted instruction situation, whether it be a mainline or adjunct application, students' progress must be continually monitored to ensure that pertinent sections of the courseware have been completed.

The results of this study indicate that students learn equally well from each of the three instructional strategies. To a large degree, economic considerations or the author's personal preference would likely dictate which instructional strategy should be used.

If the instructional designer wishes to introduce a degree of learner control, the student might be allowed to choose one of the instructional strategies. For the student to be able to make an informed choice, provision should be made for the student to sample each of the instructional strategies. Economic considerations would again enter the scene, as all instructional strategies and learner control would need to be provided throughout the courseware.

Suggestions for Further Research

The application of the three instructional strategies to larger samples from different populations (for example, university students, junior high students, students with special needs) is recommended. The interaction of differing levels of cognitive processing and differing levels of language and instructional strategies used in courseware is an important area to be studied.

The actual length of instruction in this study was only 20 minutes. An application of the three instructional strategies to courseware which is 30 to 50 hours in length might yield trends which are not evident in the teaching of a single concept.

References

Anderson, R. C. and Faust, G. *Educational Psychology: The Science of Instruction and Learning.* New York: Dodd,Mead and Co., 1974.

Anglin, J. M. *Word, Object and Conceptual Development.* New York: Norton, 1977.

Ausubel, D. P. Meaningful Reception Learning and the Acquisition of Concepts. In Klausmeier, H. J. and Harris, C. W. (Eds.) *Analyses of Concept Learning.* New York: Academic Press, 1966.

Baine, D. *Instructional Design for Special Education.* Englewood Cliffs N.J. : Educational Technology Publications, 1982.

Baine, D. *Teaching Discriminations and Concepts to Severely Handicapped Persons.* TASH Conference, San Francisco , 1983.

Berlyne, D. E. *Structure and Direction in Thinking.* New York: Wiley, 1965.

Bourne, L. E. , Dominowski, R. L. and Loftus E. F. *Cognitive Processes.* Englewood Cliffs N. J. : Prentice-Hall, 1979.

Bruner, J. S. , Goodnow, J. J. and Austin, G. A. *A Study of Thinking.* New York: Wiley, 1956.

Bunderson, C. V. *Current Issues in the United States Regarding CAI.* Austin: Computer Assisted Instruction Laboratory, University of Texas at Austin, 1970.

Carroll, J. B. Words, Meanings and Concepts. *Harvard Educational Review,* 1964, *34,* 178-202.

Chambers, J. A. and Sprecher, J. W. *Computer-Assisted Instruction Its Use in the Classroom.* Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Dimension Authoring Language Reference Manual. Maynard, Massachusetts: Digital Equipment Corporation, 1982.

Dimension Authoring System User's Guide. Maynard, Massachusetts: Digital Equipment Corporation, 1982.

Dominowski R. L. How Do People Discover Concepts. In Solso, R. (Ed.) *Theories in Cognitive Psychology: The Loyola Symposium*. Potomac,Maryland: Lawrence Erlbaum Associates, 1974.

Flavell, J. H. Concept Development. In P. H. Mussen(Ed.), *Carmichael's Manual of Child Psychology*. Vol 1 New York: Wiley, 1970.

Gagne, R. M. Learning of Principles. In Klausmeier, H. J. and Harris, C. W. (Eds.) *Analyses of Concept Learning. New York: Academic Press, 1966.*

Gagne, R. M. Conditions of Learning. New York: Holt, Rinehart and Winston, 1977.

Garroway, T. *Microcomputer Based CAL System:Castle.* Unpublished masters thesis. University of Alberta, Edmonton Alberta, 1983.

Gentile, J. R. The First Generation of Computer-Assisted Instructional Systems: An Evaluative Review. *AV Communications Review*, 1967, *15, No. 1.*

George, F. H. *Cognition*. London: Methuen and Company Ltd. , 1962.

Gleitman, L. R. Armstrong S. L. and Gleitman H. On Doubting the Concept 'Concept'. In E. K. Scholnick (Ed.) *New Trends in Conceptual Representation: Challenges to Piaget's Theory?* Hillsdale, N.J. : Erlbaum, 1983.

Gould, J. and Kolb, W. L. (Eds.) *A Dictionary of the Social Sciences*. New York: The Free Press, 1964.

Grant, L. Categorizing and Concept Learning. Preprint of a chapter to appear in *Advances in Behavior Science*

,Reese H. W. & Parrott L. J. (Eds.).

Hall K. A. Content Structuring and Question Asking for Computer Based Education. *Journal of Computer-Based Instruction*, 1983, *10 Nos. 1 & 2*, 1-7.

Haygood R. E. and Bourne L. E. Attribute and Rule Learning Aspects of Conceptual Behavior. *Psychological Review*, 1965, *72(3)*, 175-195.

Hillyard, A. L. *Stimulus Complexity During Original Learning and Generalization.* Unpublished doctoral dissertation University of Alberta , Edmonton Alberta, 1979.

Horton, D. L. and Turnage, T. W. *Human Learning.* Englewood Cliffs, N.J. : Prentice-Hall, Inc. , 1976.

Hotelling, H. *A Generalized T Test and Measure of Multivariate Dispersion.* Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability. Berkeley,California: University of California Press, 1951.

Hull, C. H. and Nie, N. H. *SPSS Update 7-9 New Procedures and Facilities for Releases 7-9.* New York: McGraw-Hill, 1981.

Kearsley, G. P. *Instructional Design in CAI.* Edmonton Alberta: Division of Educational Research Services, Faculty of Education, University of Alberta, 1977.

Kendler, H. H. The Concept of the Concept. In N. W. Melton (Ed.) *Categories of Human Learning.* New York: Academic Press, 1964.

Klausmeier, H. J. *Learning and Teaching Concepts: A Strategy for Testing Applications of Theory.* New York: Academic Press, 1980.

Klausmeier H. J. and Associates *Cognitive Learning and Development: Information Processing and Piagetian Perspectives.* Cambridge, MA: Ballinger Publishing, 1979.

Klausmeier, H. J. Ghatala, E. S. and Frayer D. A. *Conceptual Learning and Development: A Cognitive View.* New York: Academic Press, 1974.

Klausmeier, H. J. , and Harris C. W. (Eds.) *Analyses of Concept Learning.* New York: Academic Press, 1966.

Klausmeier, H. J. and Hooper, F. H. Conceptual Development and Instruction. In F. N. Kerlinger (Ed.) *Review of Research in Education.* Itasca, Illinois: Peacock, 1974.

Klausmeier, H. J. Sipple, T. S. and Frayer D. A. *An Individually Administered Test to Assess Level of Attainment and Use of the Concept Equilateral Triangle* (Tech. Rep. No 257). Madison, Wisconsin: Research and Development Center for Cognitive Learning, 1973.

Markle, S. M. and Tiemann, P. W. *Really Understanding Concepts.* Champaign Illinois: Stipes, 1969.

Martorella, P. H. , Jensen, R. S. , McKean, J. and Voelker, A. M. *Concept Learning; Designs for Instruction.* Scranton: Intex Educational Publishers , 1972.

Medin D. L. and Smith D. E. Concepts and Concept Formation. *Annual Review of Psychology*, 1984, *35*, 113-138.

Merrill, M. D. and Tennyson, R. D. *Teaching Concepts: An Instructional Design Guide.* Englewood Cliffs N. J. : Educational Technology Publishers, 1977.

Millward R. B. Models of Concept Formation. In R. E. Snow, P. Federico and W. E. Montague (Eds.) *Aptitude, Learning and Instruction: Cognitive Process Analysis of Learning and Problem Solving (Vol 2)* . Hillsdale, N. J. : Erlbaum, 1980.

Morrison, D. F. *Multivariate Statistical Methods.* New York: McGraw-Hill, 1976.

Osgood, C. E. *Method and Theory in Experimental Psychology.* London and New York: Oxford University Press, 1953.

Park O. Example Comparison Strategy Versus Attribute Identification Strategy in Concept Learning. *American Educational Research Journal*, 1984, *21 No. 1*, 145-162.

Pillai K. C. S. Upper Percentage Points of the Largest Root of a Matrix in Multivariate Analysis. *Biometrika*, 1967 *54*, 189-193.

Quillen, I. J. and Hanna, L. A. *Education for Social Competence (Rev Ed.)*. Chicago: Scott, Foresman and Company, 1961.

Rey G. Concepts and Stereotypes: A Critical Discussion of Categories and Concepts. *Cognition*, 1984, *15(1-3)*, 237-262.

Rips L. J. , Shoben, E. J. and Smith, E. E. Semantic Distance: A Verification of Semantic Relations. *Journal of Verbal Learning and Behavior*, 1973, *12*, 1-20.

Rosch E. H . Natural Categories. *Cognitive Psychology* , 1973, *4*, 328-350.

Rosch, E. H. Cognitive Representations of Semantic Categories. *Journal of Experimental Psychology*, 1975, *104* , 192-223.

Rosch, E. H. Principles Of Categorization. In E. H. Rosch and B. Lloyd (Eds.) *Cognition and Categorization.* Hillsdale, N. J. : Erlbaum, 1978.

Rosch, E. H. and Lloyd, B. (Eds.) *Cognition and Categorization.* Hillsdale, N. J. : Erlbaum, 1978.

Roy, S. N. *Some Aspects of Multivariate Analysis.* New York: John Wiley & Sons, 1957.

Smith E. E. and Medin D. L. *Categories and Concepts.* Cambridge, MA: Harvard University Press, 1981.

Tennyson, C. L. Tennyson, R. D. and Rothen, W. Content Structure and Instructional Control Strategies as Design Variables in Concept Acquisition. *Journal of*

Educational Psychology, 1980, *72*, 499-505.

Tennyson, R. D. Chao, J. N. and Youngers, J. Concept Learning Effectiveness, using Prototype and Skills Development Presentation Forms. *Journal of Educational Psychology* , 1981, *73*, 326-334.

Tennyson, R. D. , Christenson,D. L. and Park S. I. The Minnesota Adaptive Instructional System: An Intelligent CBI System. *Journal of Computer-Based Instruction*, 1984, *11 No. 1*, 2-13.

Tennyson, R. D. and Jassal, R. S. Application of Concept Learning Research in the Design of Instructional Systems. *International Journal of Instructional Media*, 1981-82, 9, 185-205.

Tennyson, R. D. and Park, O. The Teaching of Concepts: A Review of the Instructional Design Literature. *Review of Educational Research* , 1980, *50*, 55-70.

Tennyson, R. D. and Park, O. Introduction to Special Issue. *Journal of Computer-Based Instruction*, 1984, *11 No. 1* , 1.

Tennyson R. D. Youngers, J. and Suebsonthi, P. Concept Learning by Children using Instructional Presentation Forms for Prototype Formation and Classification -Skill Development. *Journal of Educational Psychology*, 1983, *75*, 280-291.

Towle N. J. *Designing Computer Assisted Instruction.* Presentation at Convention of Association for Educational Communications and Technology. Kansas City: 1978.

Wilks S. S. Certain Generalizations in the Analysis of Variance. *Biometrika*, 1932, *24*, 471-494.

Wittgenstein, L. *Philosophical Investigations.* New York: Macmillan, 1953.

Appendix A

Responses Right and Wrong on Postest and Retention Test

Question 1

	Posttest W	Posttest R	Total
Retention test R	7	37	44
Retention test W	4	0	4
Total	11	37	48

Question 2

	Posttest W	Posttest R	Total
Retention test R	1	43	44
Retention test W	0	4	4
Total	1	47	48

Question 3

	Posttest W	Posttest R	Total
Retention test R	10	21	31
Retention test W	10	7	17
Total	20	28	48

Question 4

	Posttest W	Posttest R	Total
Retention test R	11	27	38
Retention test W	6	4	10
Total	17	31	48

Question 5

	Posttest W	Posttest R	Total
Retention test R	6	39	45
Retention test W	1	2	3
Total	7	41	48

Question 6

	Posttest W	Posttest R	Total
Retention test R	16	28	44
Retention test W	1	3	4
Total	17	31	48

Question 7

	Posttest W	Posttest R	Total
Retention test R	1	40	41
Retention test W	2	5	7
Total	3	45	48

Question 8

	Posttest W	Posttest R	Total
Retention test R	9	37	46
Retention test W	2	0	2
Total	11	37	48

Question 9

	Posttest W	Posttest R	Total
Retention test R	8	29	37
Retention test W	7	4	11
Total	15	33	48

Question 10

	Posttest W	Posttest R	Total
Retention test R	15	21	36
Retention test W	10	2	12
Total	25	23	48

The critical chi square(1) at 0.05 level of significance is 3.841. The significant chi square values

were 15.68 for Question 1, 6.97 for Question 7, 7.02 for Question 8, 6.96 for Question 9 and 6.26 for Question 10.

Appendix B

Number of Questions Correct by Treatment Group

Attribute Identification Strategy

	On-task	Posttest	Retention
STUDENT1	4.29	8	6
2	10	9	10
3	10	8	9
4	5.71	9	8
5	8.57	9	9
6	8.57	7	8
7	10	6	10
8	7.14	4	8
9	7.14	5	3
10	10	10	10
11	2.86	5	6
12	10	8	9
13	10	8	10
14	8.57	6	7
15	4.29	7	7
16	8.57	5	5

Example Comparison Strategy

	On-task	Posttest	Retention
Student1	8.57	8	8
2	5.71	6	8
3	8.57	8	9
4	10	8	9
5	5.71	6	9
6	7.14	7	9
7	7.14	8	10
8	5.71	8	9
9	7.14	6	6
10	5.71	9	6
11	10	8	7
12	7.14	8	10
13	8.57	9	9
14	8.57	8	10
15	7.14	7	7
16	7.14	8	9

AIS/ECS

	On-task	Posttest	Retention
Student 1	7.14	5	8
2	10	8	9
3	10	6	8
4	5.71	8	10
5	10	7	8
6	8.57	6	9
7	5.71	4	5
8	5.71	9	10
9	8.57	7	10
10	5.71	7	9
11	10	8	10
12	10	8	10
13	8.57	10	10
14	5.71	8	10
15	8.57	9	10
16	8.57	7	10

Appendix C

Sample of Acceptable and Unacceptable Definitions

Five acceptable and five unacceptable definitions provided by the students were selected and are shown below. An acceptable definition was one agreed upon by two or more of the three subject matter experts (SME) . The definitions are shown verbatim (including capitalization).

Acceptable

•An experiment that contains a number of factors that predictable, common and different every time. (2 of 3 SME s)

•Something that is decided by chance, where there is no greater probability for a specific outcome than for any other of the other possible outcomes. (3 of 3 SME s)

•Something you have no control over. Whatever you get, you get. (2 of 3 SME s)

•choosing an object without knowing the end result, from a group of objects of which ONE can be diffentiated from The Rest.(3 of 3 SME s)

•An experience done by chance and repeated. (3 of 3 SME s)

Unacceptable

•An experiment where the results can be predicted. (2 of 3 SME s)

•An experiment that can be conducted on a set number of items to determine outcomes or results. (3 of 3 SME s)

•An experiment selected at random choice. The elements within the experiment are randomly chosed. (3 of 3 SME s)

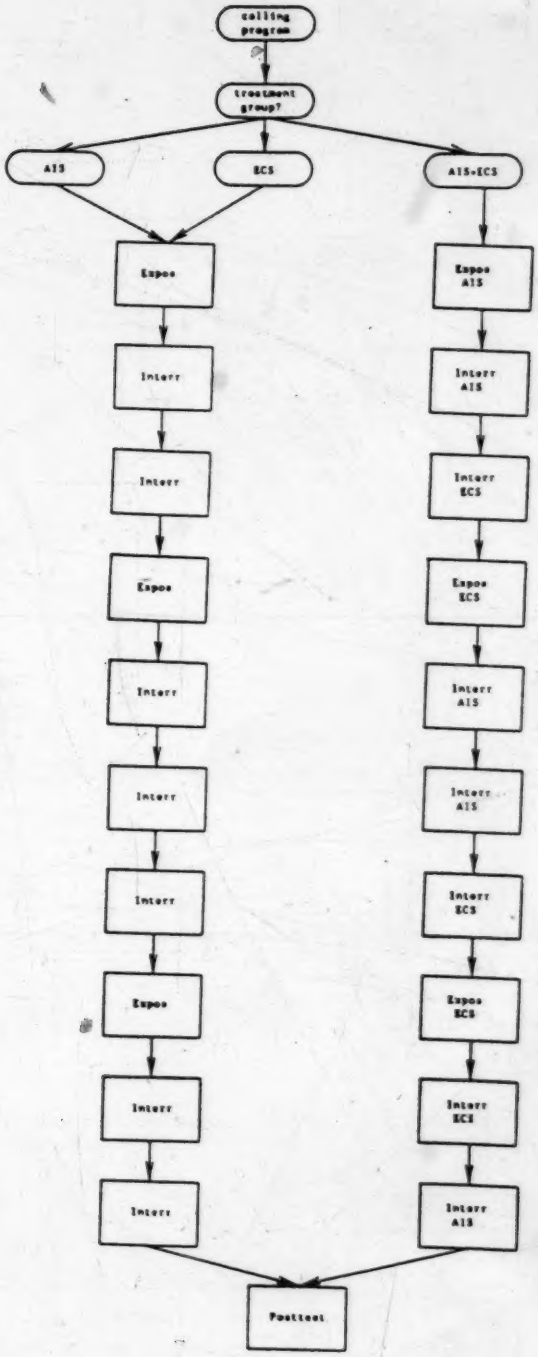
•A random experiment makes me think of a process where you do something a certain number of times and come up with a

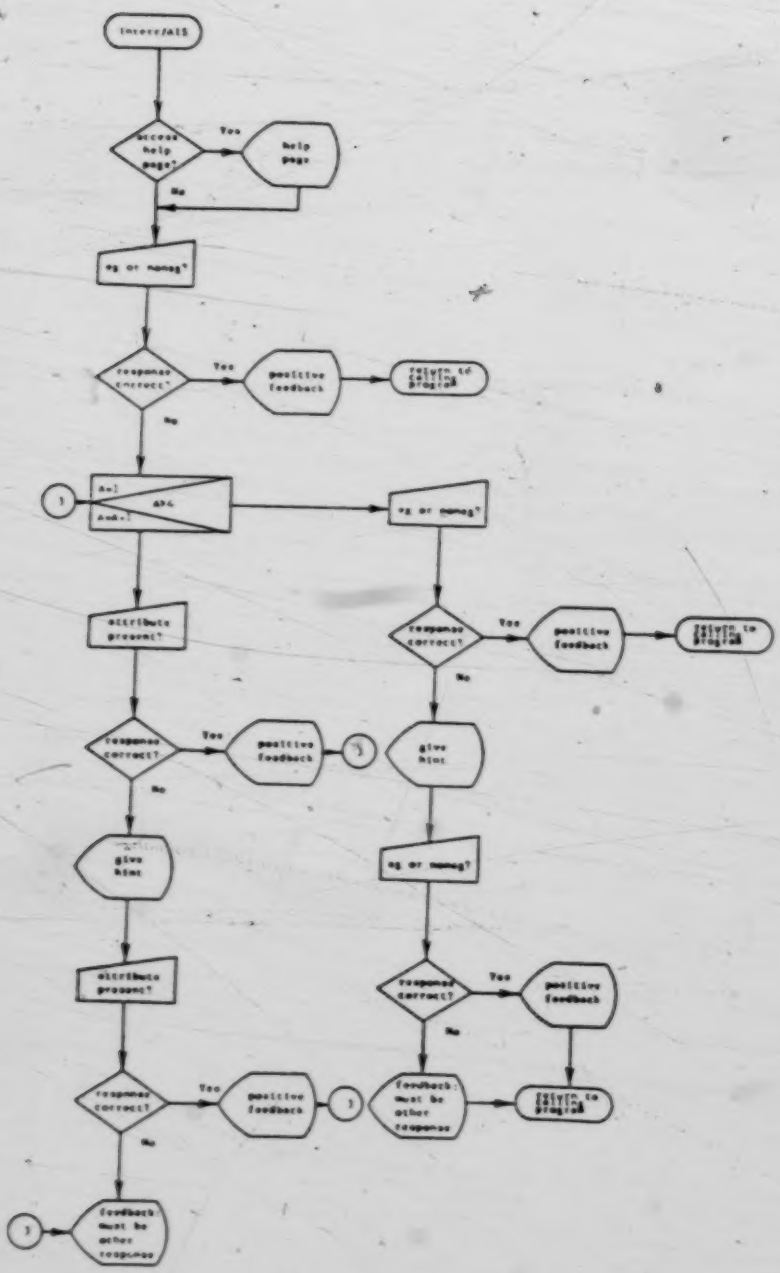
average of what will occur if that action is done that certain amount of time. (2 of 3 SME s)

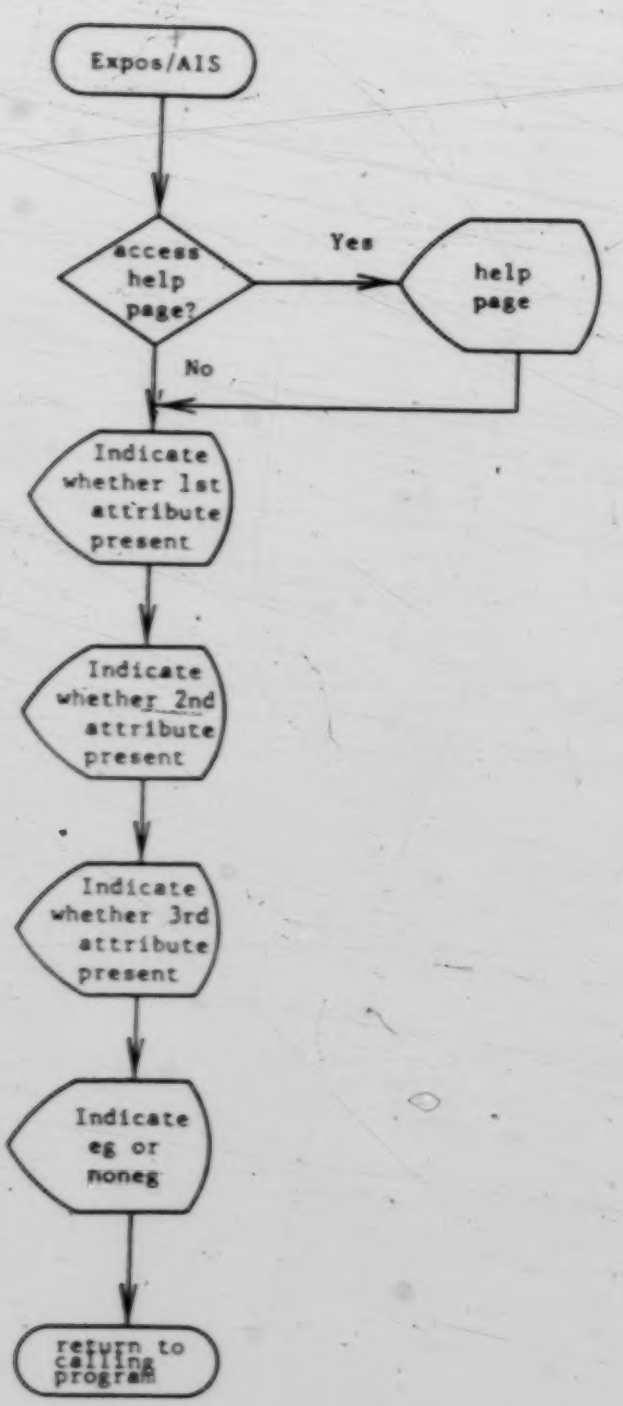
•An experiment designed to find the outcome of a set of variable actions. (3 of 3 SME s)

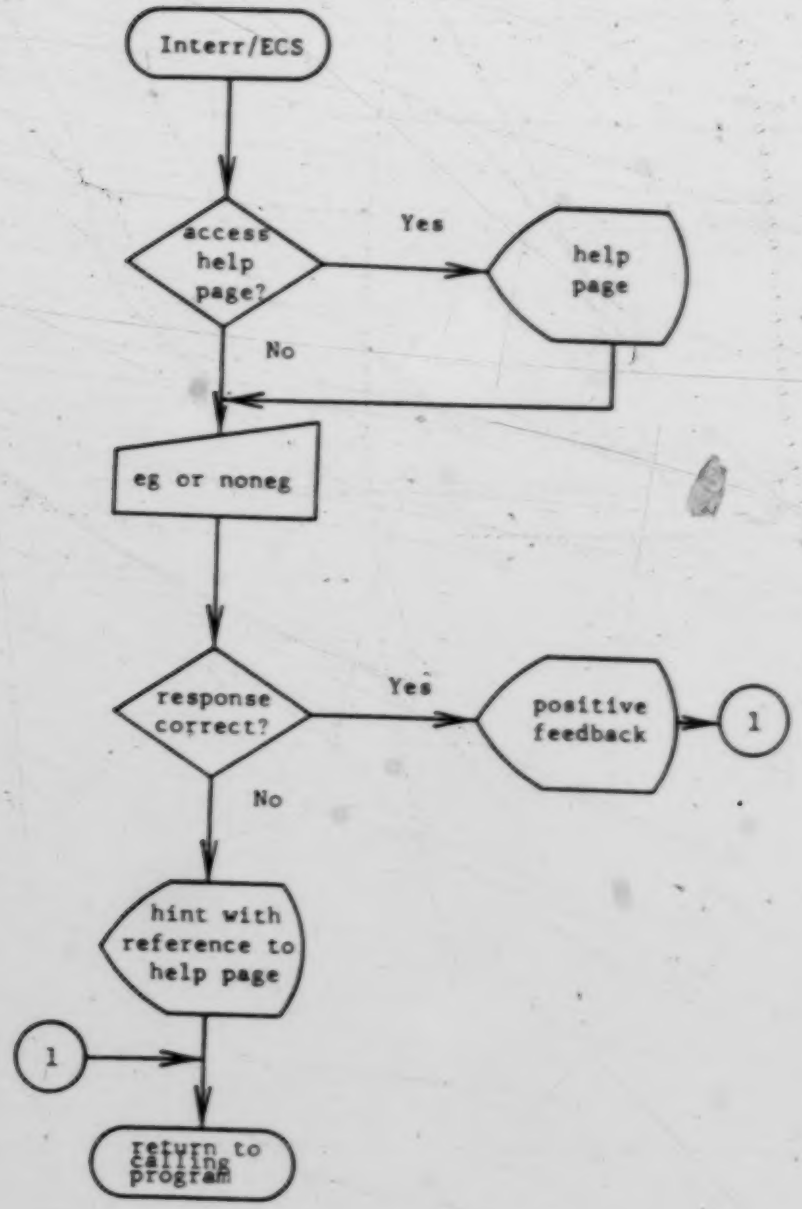
Appendix D

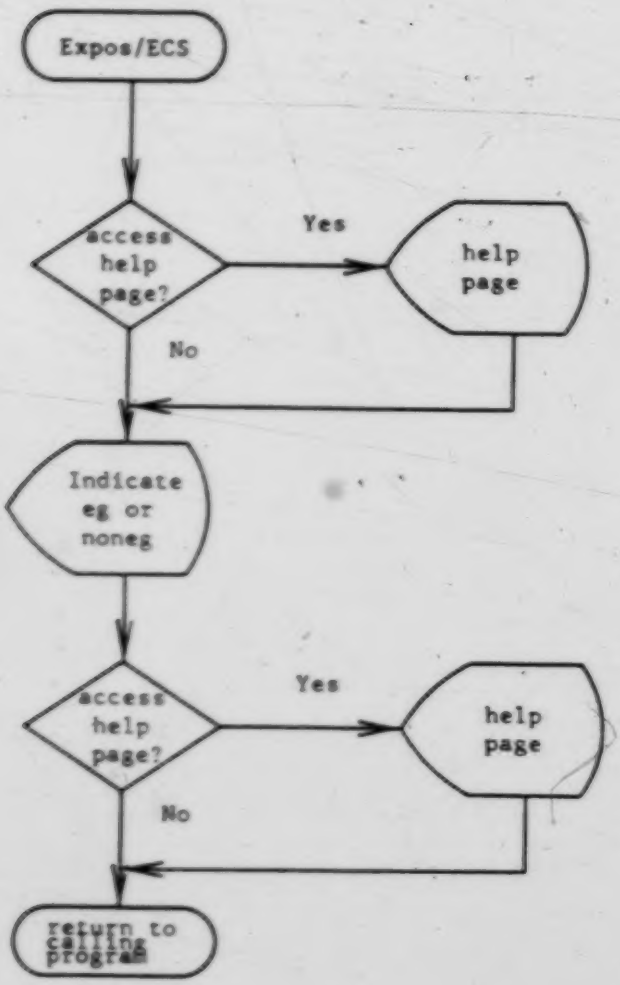
Flowcharts Showing Presentation Algorithms


calling program
treatment group?
AIS
ECS
AIS+ECS
Expos
Interr
Interr
Expos
Interr
Interr
Interr
Expos
Interr
Interr
Posttest
Expos AIS
Interr AIS
Interr ECS
Expos ECS
Interr AIS
Interr AIS
Interr ECS
Expos ECS
Interr ECS
Interr AIS


Yes
No
Yes
No
Yes
No
Yes
No
Yes
No
Yes
No


Expos/AIS
access help page?
Yes
help page
No
Indicate whether 1st attribute present
Indicate whether 2nd attribute present
Indicate whether 3rd attribute present
Indicate eg or noneg
return to calling program


Interr/ECS
access help page?
Yes
help page
No
eg or noneg
response correct?
Yes
positive feedback
1
No
hint with reference to help page
1
return to calling program


Expos/ECS
access help page?
Yes
help page
No
Indicate eg or noneg
access help page?
Yes
help page
No
return to calling program

Appendix E

Posttest and Retention Test Questions

Question 1

Randomly choose 20 people .
Determine the number of people with blood type o,a,b respectively.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 2

John receives the same amount of gross pay every week.
Is the receipt of his paycheque a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 3

Randomly choose a business administration class.
The outcome of interest is the number of males and females in the class.
The number of students in each class is unknown.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 4

Draw a ball from an empty peanut butter jar.
The outcome of interest is the color of the ball.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 5

Randomly choose 5 people .
Ask them if they would vote Liberal,Conservative,NDP,Other or are Undecided. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 6

Randomly select a business administration student.
The outcome of interest is whether the student is male or female.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 7

Observe the moon with a telescope and observe
the number of kangaroos you see.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 8

Randomly select 100 people and count the number
of people who smoke. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 9

Flip a coin 10 times on a hard flat surface
and count the number of times it lands on its
edge. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 10

Read the temperature on a thermometer outside your bedroom
window at 8:00 A.M. each morning.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Appendix F

Sample of the Courseware for AIS/ECS group

Northern Alberta Institute of Technology
11762-106 st. Edmonton, Alberta, Canada, T5G 2R1

NAIT

RANDOM EXPERIMENT

GROUP	BUSINESS ADMINISTRATION
LESSON	STATISTICS : SEGMENT 1

Press RETURN to begin the lesson

Authors Page

The following people authored this lesson :

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With valued advice from Eric Goodman

Programmed by :
Neil Moore with valued advice from Diane Bowes

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Press RETURN to continue

Do you want to see the keyboard conventions for this lesson?

Please enter yes or no >N

All questions will answered with yes or no.
You may use y or n if you wish.

Press RETURN to continue

Overview

The lesson consists of 2 parts:

Presentation	-16 screens
Evaluation	-10 screens

The presentation consists of 3 parts:

Definition of random experiment	-1 screen
Processes	-2 screens
Outcomes	-3 screens
Random experiment - examples and nonexamples	-10 screens

Press RETURN to continue

Why learn about probability?

It will help you to assess your chances at the race track, casino or just playing crib with Gramma.

It is a necessary building block for statistics.

Why learn this material on the computer?

1) You can proceed at your own pace.
2) Some examples can be presented in a form impossible in a normal classroom.
3) You are helping the author.

Press RETURN to continue

Definition 1 of 1
Lesson 1 of 26

The definition of random experiment will be shown
and then processes and outcomes discussed.
It is necessary to understand what processes and outcomes
are in order to understand the definition fully.

Please do not write down the definition.
It will be available to you if needed.

A random experiment is a process
with the following 3 properties:

1. It can be repeated.

2. All possible outcomes can be identified in advance.

3. If the process is repeated many times you will not always
   get the same outcome.

Press RETURN to continue

Processes 1 of 2
Lesson 2 of 26

Experiments involve processes.

Examples of Processes:

1) Draw 3 balls from a jar containing 6 balls.
   Do not replace a ball after it has been drawn.
2) Beat 7 people at a table.
3) Draw 2 cards from a deck of cards.
4) Roll a pair of dice.
5) Pick which one of your girlfriend's (or boyfriend's)
   hands has a present in it and which has a potato.

Press RETURN to continue

Processes 2 of 2
Lesson 3 of 26

The most important thing for you to do in the whole area of probability is to think about the process.

Take the following 2 processes:

1) Draw 2 balls from a jar containing 6 balls.
   Do not replace the 1st ball before you draw the 2nd.

2) Draw 2 balls from a jar containing 6 balls.
   Replace the 1st ball before you draw the 2nd.

Press RETURN to continue

Press PF2 to go back

Outcomes- 1 of 3
Lesson - 4 of 26

You can see from the previous page that if there is
1 red ball and 5 black balls the 1st process(without replacement)
cannot yield a result of 2 red balls while the 2nd process
can yield that result.

The results of an experiment are called outcomes.
We see again the importance of the process.
Outcomes must be looked at in conjunction with the process.
Let's look at some more processes.

Press RETURN to continue

Press PF2 to go back

Outcomes 2 of 3
Lesson 5 of 26

Draw a ball from a jar containing 6 identical red unnumbered balls.
There would be 6 outcomes in this case:

red ball
red ball
red ball
red ball
red ball
red ball

Deal a card from a deck containing only the 26 red cards.
The 26 outcomes in this case would be : A to K of Hearts
A to K of Diamonds

Press PF2 to go back

Press RETURN to continue

Outcomes 3 of 3
Lesson 6 of 26

A die is rolled twice.
The possible outcomes are:

First roll	1	1	1	1	1	1
Second roll	1	2	3	4	5	6
First roll	2	2	2	2	2	2
Second roll	1	2	3	4	5	6

and so on.

Press PF2 to go back

Press RETURN to continue

You have spent a considerable amount of time
learning about process and outcomes.

You will now use that information to help you identify
whether a given process is a random experiment or not.
The short test at the end of the lesson will be very similar
to the random experiment section as you will again be
asked whether a process is a random experiment or not.

In 5 of the 10 processes in the random experiment section
you will be presented with the definition you saw previously.
Press help if you have forgotten it.
You will be able to access this help page in the random experiment
section.

Press F1 for help

Press RETURN to continue

In the case of the other five processes,
instead of providing you with the definition,
you will be provided with 2 best examples.

Please do not be frustrated with this change.
The author is experimenting in an attempt to improve the
teaching and learning process.

Press the help key to see 2 best examples of the concept
of random experiment.
In the random experiment section you will be able to
access this help page when applicable.
Compare each process given to the examples to determine
whether the process is an example of random experiment or not.

Press F1 for help

Press RETURN to continue

Help Page

A random experiment is a process with the following properties:

1. It can be repeated.

2. All possible outcomes can be identified in advance.

3. If the process is repeated many times you will not always get the same outcome.

Press RETURN to go back to the appropriate page.

Help Page

Here are 2 excellent examples of the concept of random experiment.

Study them carefully.

1. Draw a ball from a container with SEVEN colored balls.

   THREE are red and FOUR are yellow.

   The outcome of interest is the COLOR of the ball drawn.

2. RANDOMLY choose a business administration class.

   There are FORTY students in each class.

   The outcome of interest is the number of

   MALES and FEMALES in the class.

Press RETURN to go back to the appropriate page.

Random Experiment 1 of 10
Lesson 7 of 26

CONSIDER THIS PROCESS.

Roll 2 dice.
Calculate the sum of the points on the 2 dice.
Is this a random experiment?

It can be repeated.

The outcomes can be specified in advance.

If the process is repeated many times you will not get the same outcome.

Therefore this is an example of a random experiment.

Press RETURN to continue

Consider this process.

Random Experiment 2 of 10
Lesson — 8 of 26

Flip a coin 10 times on a hard flat surface and count the number of times it lands on its edge.
Is this a random experiment? >n

correct

Press RETURN to continue

Consider this process.

Random Experiment 3 of 10
Lesson 9 of 26

Seat 7 people at a round table and observe the seating arrangement.
Is this a random experiment?

Before you press return ask yourself whether this process has similar characteristics to the 2 best examples of random experiment. Press help if you have forgotten them.

Press PF1 for help

Press RETURN to continue

Random Experiment 4 of 10
Lesson 10 of 26

CONSIDER THIS PROCESS.

Draw a ball from a jar containing 6 identical yellow unnumbered balls.
Is this a random experiment?

The balls in this example are all the same color while those in the first of the best examples are different colors.

Press PF1 for help

Press RETURN to continue

Consider this process.

Random Experiment 6 of 10
Lesson 11 of 26
type of reading:

Imagine a digital watch which has the following 1984 Feb 19 13:30. The watch cannot be stopped.
Is the operation of this watch a random experiment? >y

Incorrect- You will be asked each attribute separately.

Press RETURN to continue

Consider this process.

Random Experiment 6 of 10
Lesson 11 of 26
type of reading:

Imagine a digital watch which has the following 1984 Feb 19 13:30. The watch cannot be stopped.

Can the process be repeated? >y Think about your answer again.
Only Captain Kirk can go back in time.

Enter Answer
Press RETURN to continue

Consider this process.

Random Experiment 6 of 10
Lesson 12 of 26

A red die is thrown.
The outcome of interest is the number appearing on the face of the die.

Can the process be repeated?	yes
Can all possible outcomes be identified in advance?	yes
If the process is repeated many times will you get different outcomes?	yes

Is the process therefore a random experiment? >y Very Good.

Press RETURN to continue

Consider this process.

Random Experiment 7 of 10
Lesson 13 of 26

A die is submerged in red paint.
The outcome of interest is the color of the face that is on top when the die lands after being thrown.
Is this a random experiment? >

Enter Answer
Press RETURN to continue

Random Experiment 9 of 10
Lesson 14 of 26

CONSIDER THIS PROCESS.

Imagine a coin with 2 sides.
Flip it an unspecified number of times.
The outcomes of interest are the number of heads and tails.
Is this a random experiment?

In the 2 best examples you know there are 40 people
in the room and 7 balls in the container.
Here, you do not know the number of times the coin is flipped.

Press PF1 for help

Press RETURN to continue

Consider this process.

Random Experiment 9 of 10
Lesson 15 of 26

Throw a coin 3 times.
With each throw record whether it is a head or a tail.
The outcome of interest is the number of heads
and the number of tails.
Is this a random experiment?

Before you press return ask yourself whether this process
has similar characteristics to the 2 best examples of random experiment
Press help if you have forgotten them.

Press PF1 for help

Press RETURN to continue

Consider this process.

Random Experiment 10 of 10
Lesson 16 of 26

Randomly select an Edmonton library and count the number of icebergs in the basement.
Is this a random experiment?

Before you press return ask yourself whether this process satisfies the 3 characteristics of a random experiment.
Press help if you have forgotten them.

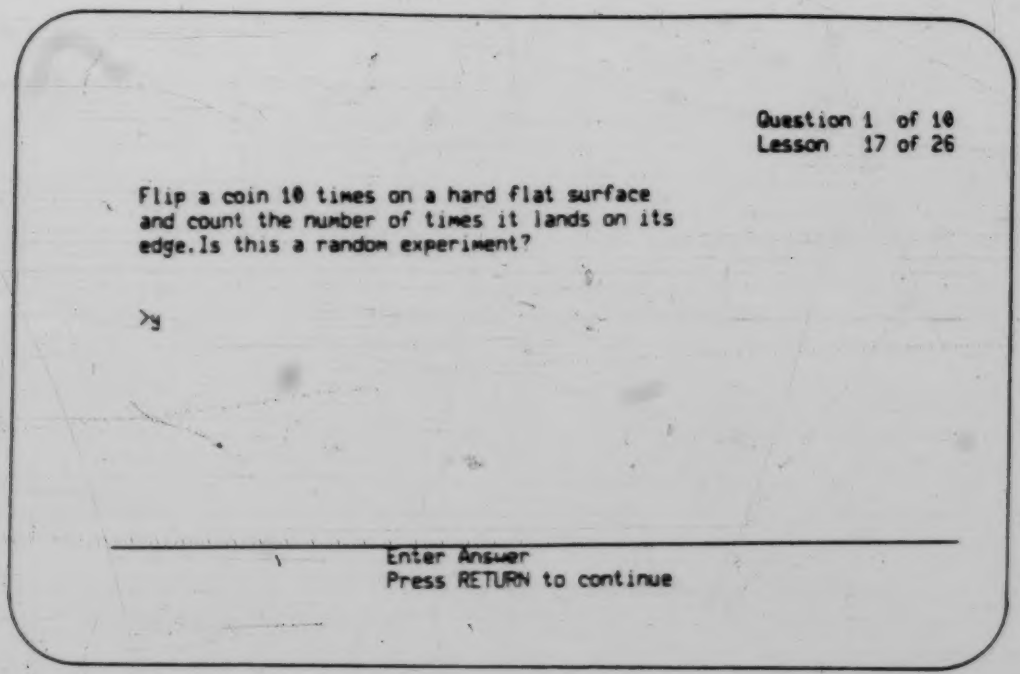
Press PF1 for help

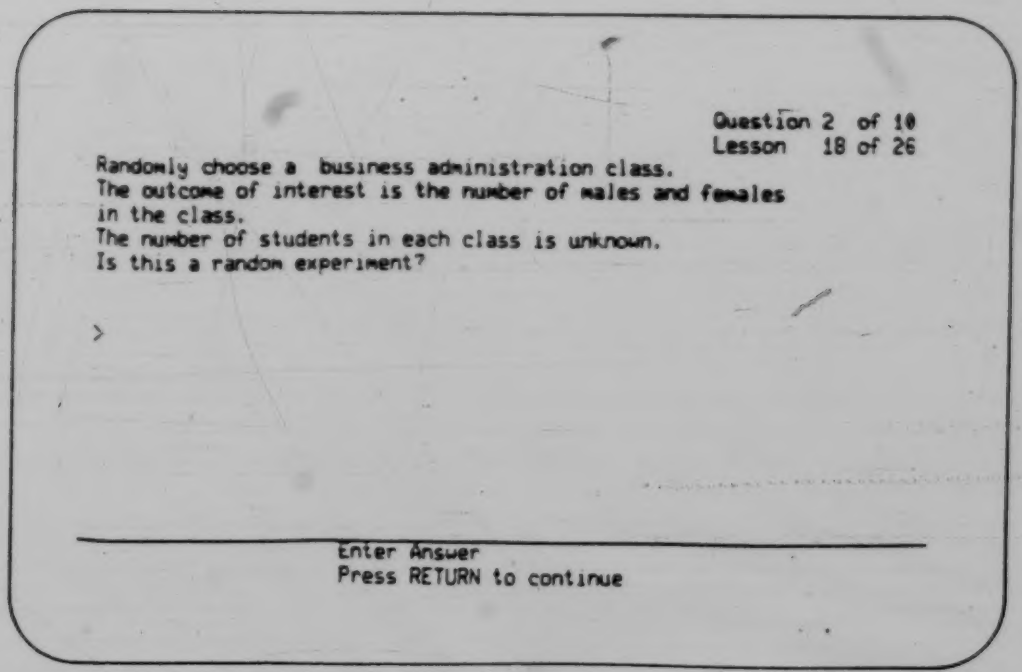
Press RETURN to continue

You are now ready to do the posttest.
Please do not be anxious .
The author has designed the posttest so that you will be able to review your answers if you wish.
You will not be told whether and individual question is right or wrong until you have been given an opportunity to review your answers.

Remember that the posttest is not an assessment of you but of how well the author has drafted and programmed the lesson.

Press RETURN to continue


Question 1 of 10
Lesson 17 of 26
Flip a coin 10 times on a hard flat surface
and count the number of times it lands on its
edge. Is this a random experiment?
>y
Enter Answer
Press RETURN to continue


Question 2 of 10
Lesson 18 of 26
Randomly choose a business administration class.
The outcome of interest is the number of males and females
in the class.
The number of students in each class is unknown.
Is this a random experiment?
>
Enter Answer
Press RETURN to continue

Question 3 of 10
Lesson 19 of 26

Read the temperature on a thermometer outside your bedroom window at 8:00 A.M. each morning.
Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 4 of 10
Lesson 20 of 26

John receives the same amount of gross pay every week.
Is the receipt of his paycheque a random experiment?

>

Enter Answer
Press RETURN to continue

Question 5 of 10
Lesson 21 of 26

Randomly select a business administration student.
The outcome of interest is whether the student is male or female.
Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 6 of 10
Lesson 22 of 26

Observe the moon with a telescope and observe
the number of kangaroos you see.
Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 7 of 10
Lesson 23 of 26

Draw a ball from an empty peanut butter jar.
The outcome of interest is the color of the ball.
Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 8 of 10
Lesson 24 of 26

Randomly choose 5 people .
Ask them if they would vote Liberal,Conservative,NDP,Other or
are Undecided. Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 9 of 10
Lesson 25 of 26

Randomly select 100 people and count the number of people who smoke. Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 10 of 10
Lesson 26 of 26

Randomly choose 20 people .
Determine the number of people with blood type o,a,b respectively.
Is this a random experiment?

>

Enter Answer
Press RETURN to continue

Question 1 of 10
Lesson 17 of 26

Flip a coin 10 times on a hard flat surface
and count the number of times it lands on its
edge. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 2 of 10
Lesson 18 of 26

Randomly choose a business administration class.
The outcome of interest is the number of males and females
in the class.
The number of students in each class is unknown.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 3 of 10
Lesson 19 of 26

Read the temperature on a thermometer outside your bedroom window at 8:00 A.M. each morning.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 4 of 10
Lesson 20 of 26

John receives the same amount of gross pay every week.
Is the receipt of his paycheque a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 5 of 10
Lesson 21 of 26

Randomly select a business administration student.
The outcome of interest is whether the student is male or female.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 6 of 10
Lesson 22 of 26

Observe the moon with a telescope and observe
the number of kangaroos you see.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 7 of 10
Lesson 23 of 26

Draw a ball from an empty peanut butter jar.
The outcome of interest is the color of the ball.
Is this a random experiment?

>

Your previous answer was n.

Enter Answer
Press RETURN to continue

Question 8 of 10
Lesson 24 of 26

Randomly choose 5 people .
Ask them if they would vote Liberal,Conservative,NDP,Other or
are Undecided. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 9 of 10
Lesson 25 of 26

Randomly select 100 people and count the number of people who smoke. Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

Question 10 of 10
Lesson 26 of 26

Randomly choose 20 people .
Determine the number of people with blood type o,a,b respectively.
Is this a random experiment?

>

Your previous answer was y.

Enter Answer
Press RETURN to continue

```
Your score was 9. You had   question  1  incorrect
                            question  2  correct
                            question  3  correct
                            question  4  correct
                            question  5  correct
                            question  6  correct
                            question  7  correct
                            question  8  correct
                            question  9  correct
                            question  10  correct
  Would you like to see the questions
  and your results?

  >

                                  Enter Answer
                                  Press RETURN to continue
```

```
  Would you like to see just the questions
  you got wrong?

  >

                                  Enter Answer
                                  Press RETURN to continue
```

1. Flip a coin 10 times on a hard flat surface and count the number of times it lands on its edge. Is this a random experiment?

Your answer "yes" was incorrect.

Press RETURN to continue

Thanks and Goodbye.
May the road rise behind you and the sun always be at your back.

Press RETURN to continue